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(54) **INTERACTIVE WRITING DEVICE AND OPERATING METHOD THEREOF USING ADAPTIVE COLOR IDENTIFICATION MECHANISM**

(71) Applicant: **INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE**, Hsinchu (TW)

(72) Inventors: **Yi-Lun Wen**, Xinwu Township (TW); **Chung-Hsien Wu**, Taipei (TW)

(73) Assignee: **INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE**, Hsinchu (TW)

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G06F 3/042 (2006.01)

(52) **U.S. Cl.**

CPC ***G06F 3/03545*** (2013.01); ***G06F 3/0425*** (2013.01); ***G09G 5/02*** (2013.01); *G06F 2203/04104* (2013.01)

(58) **Field of Classification Search**

CPC G06F 3/011; G06F 345/156; G06F 345/179; G06F 3/033; G06F 3/0354; G06F 3/03545; G06F 2203/04101; G06F 3/03542

See application file for complete search history.

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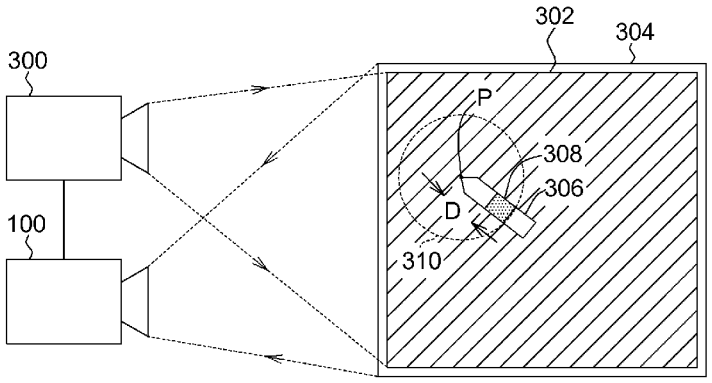
Primary Examiner — Premal Patel

(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

An operating method for an interactive writing device is provided. The operating method includes following steps. A visible light image is captured in response to an original outputted image. A tag searching region is established in the visible light image in response to a writing operation performed by a writing object having a color tag pattern. The original outputted image corresponding to the tag searching region is filtered from the visible light image in the tag searching region to generate a local processed image. A color tag corresponding to the color tag pattern of the writing object is searched from the local processed image. A color value corresponding to the color tag is generated.

12 Claims, 11 Drawing Sheets



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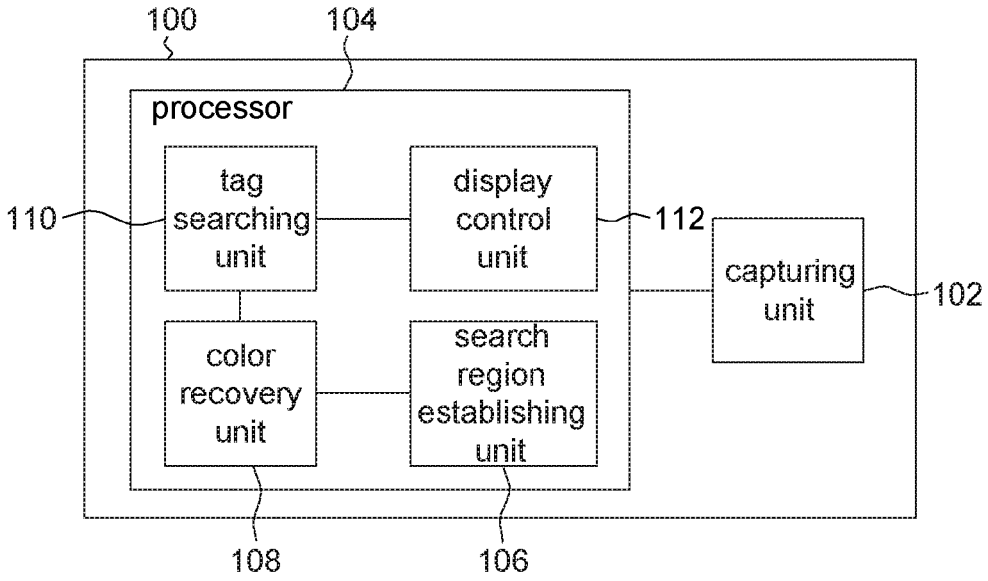
100
104
processor
tag searching unit
display control unit
110
112
capturing unit
102
color recovery unit
search region establishing unit
108
106

FIG. 1

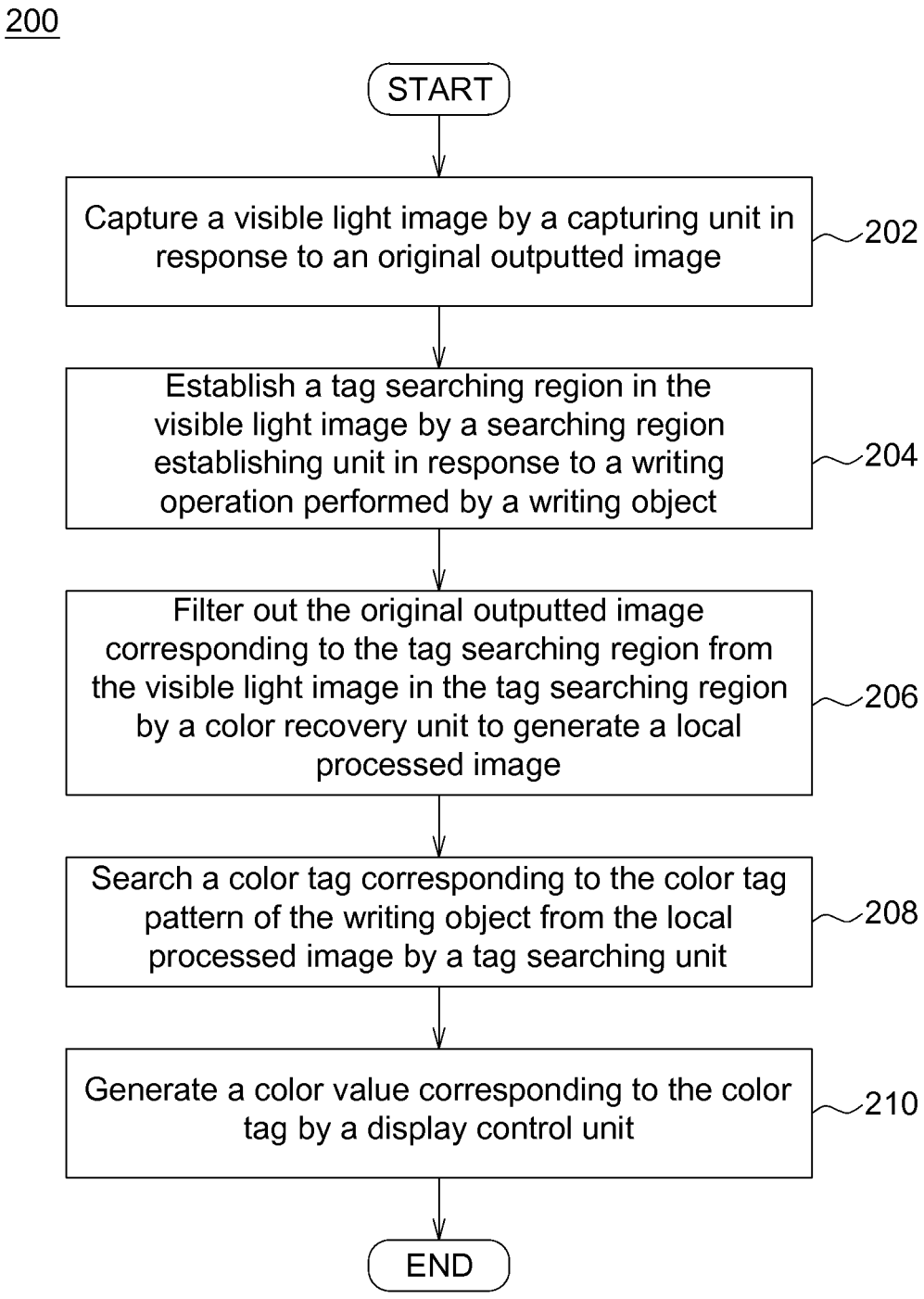
200
START
Capture a visible light image by a capturing unit in response to an original outputted image
202
Establish a tag searching region in the visible light image by a searching region establishing unit in response to a writing operation performed by a writing object
204
Filter out the original outputted image corresponding to the tag searching region from the visible light image in the tag searching region by a color recovery unit to generate a local processed image
206
Search a color tag corresponding to the color tag pattern of the writing object from the local processed image by a tag searching unit
208
Generate a color value corresponding to the color tag by a display control unit
210
END

FIG. 2

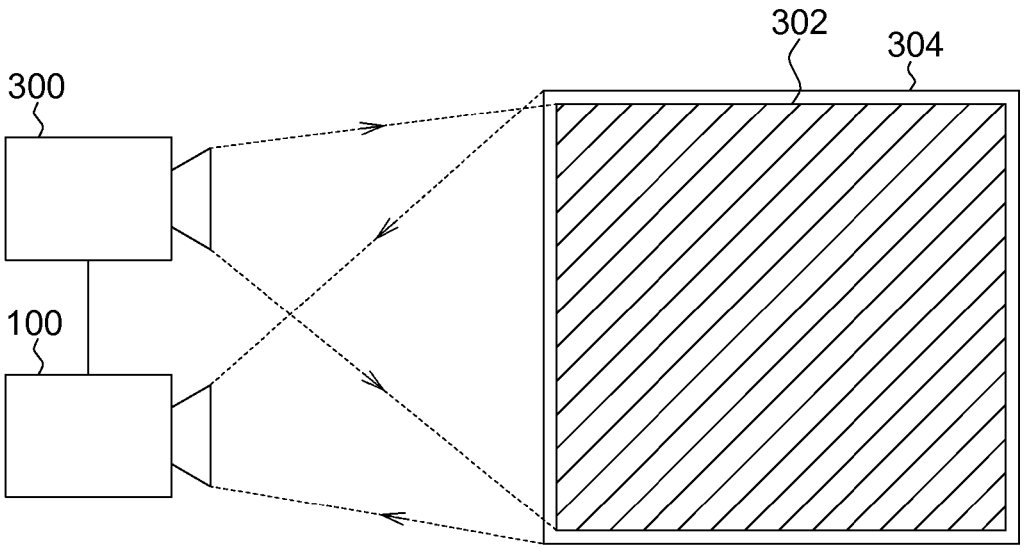

FIG. 3A

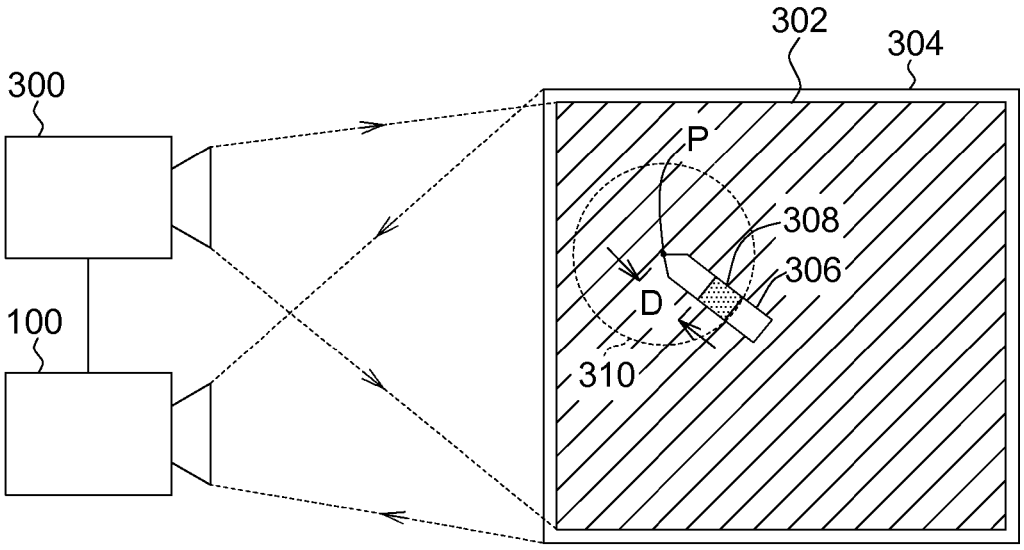

FIG. 3B

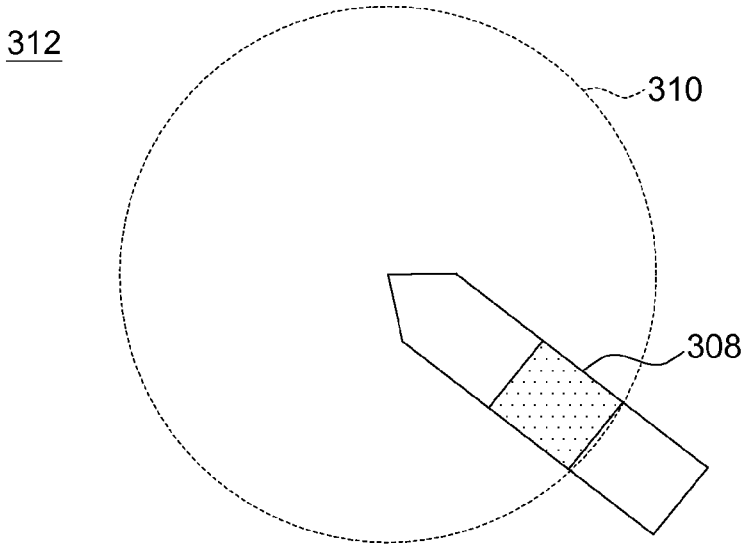

FIG. 3C

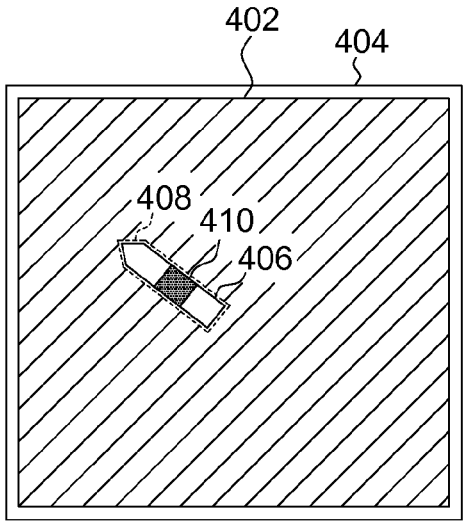

FIG. 4

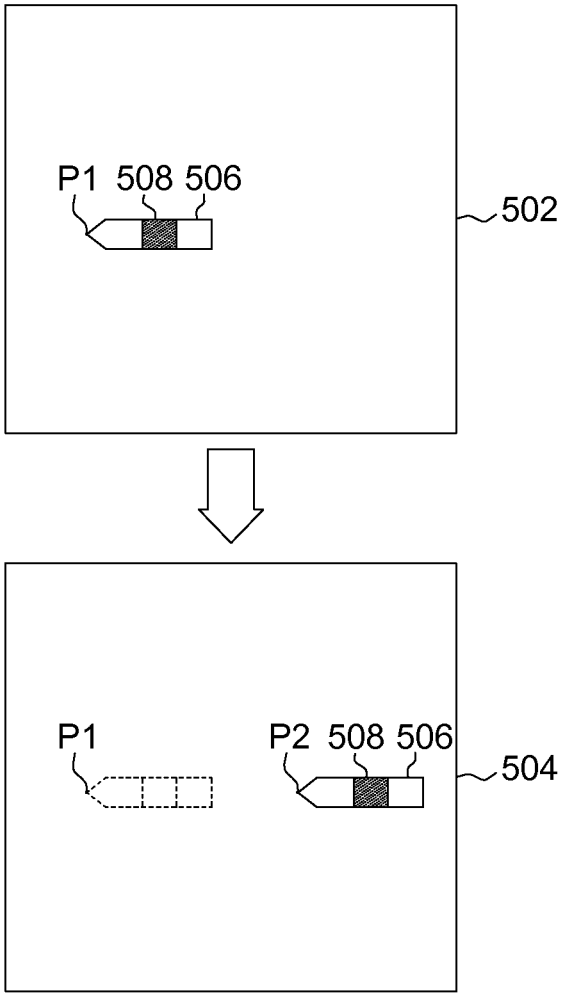

FIG. 5

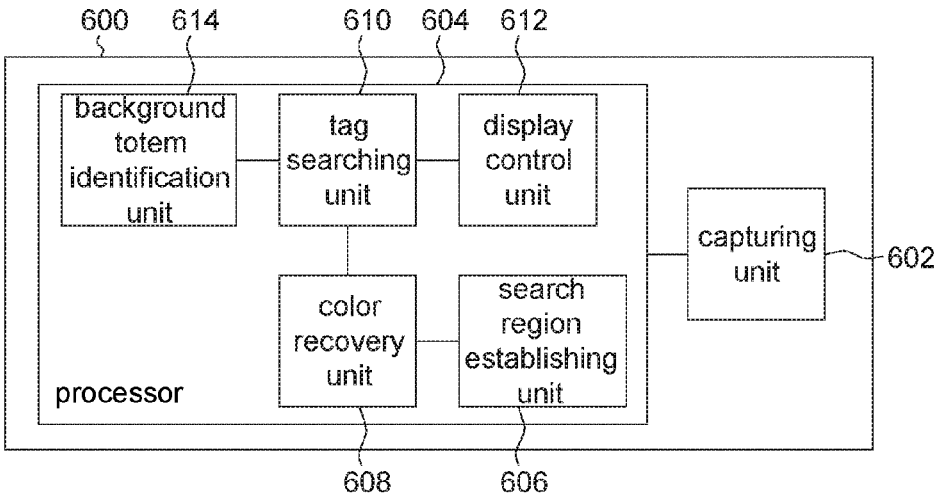
600
614
610
604
612
background totem identification unit
tag searching unit
display control unit
capturing unit
602
color recovery unit
search region establishing unit
processor
608
606

FIG. 6

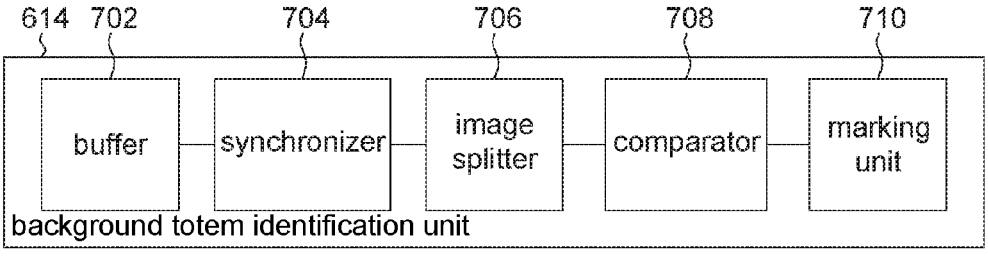
614
702
704
706
708
710
buffer
synchronizer
image splitter
comparator
marking unit
background totem identification unit

FIG. 7

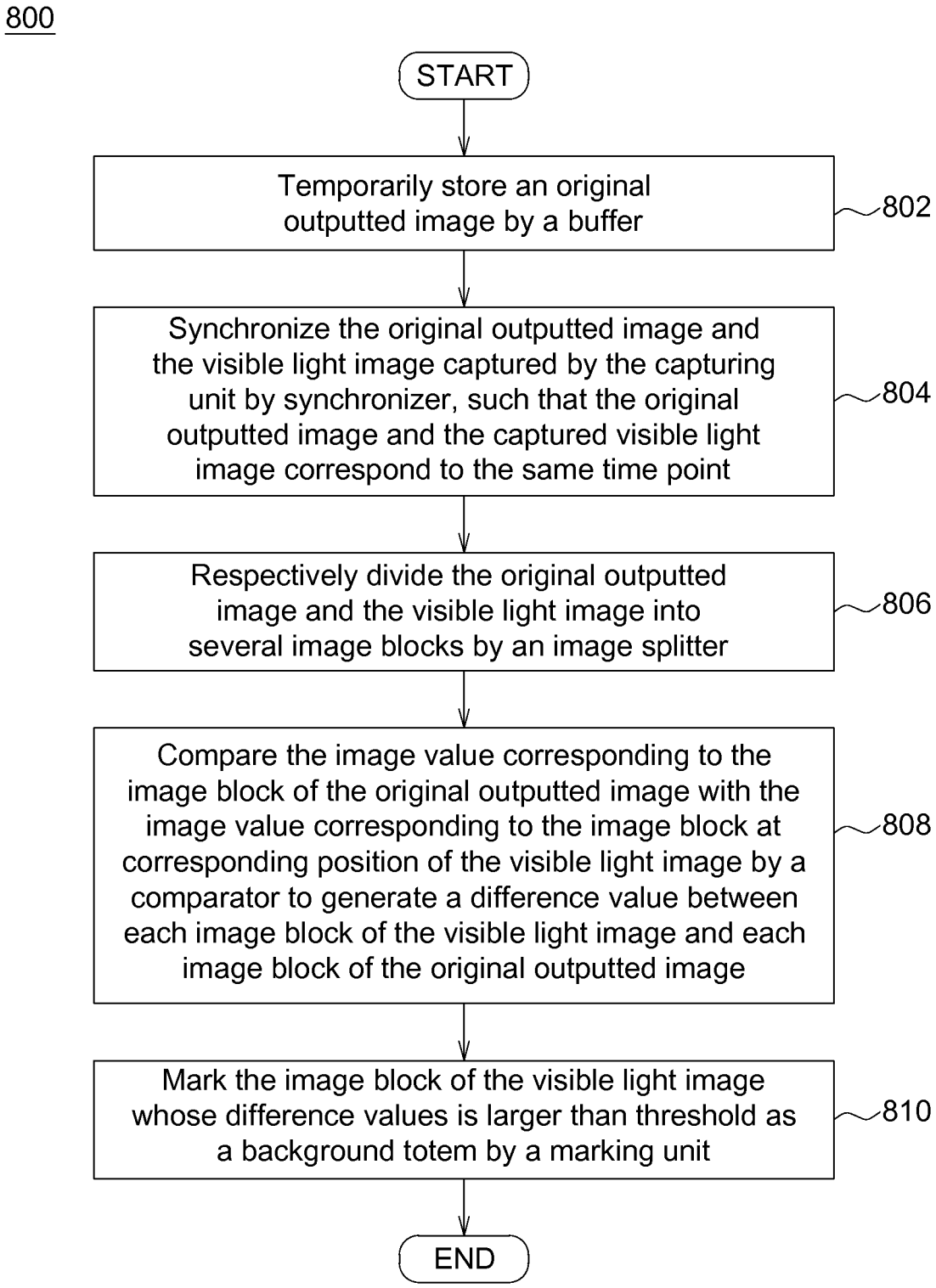
800
START
Temporarily store an original outputted image by a buffer
802
Synchronize the original outputted image and the visible light image captured by the capturing unit by synchronizer, such that the original outputted image and the captured visible light image correspond to the same time point
804
Respectively divide the original outputted image and the visible light image into several image blocks by an image splitter
806
Compare the image value corresponding to the image block of the original outputted image with the image value corresponding to the image block at corresponding position of the visible light image by a comparator to generate a difference value between each image block of the visible light image and each image block of the original outputted image
808
Mark the image block of the visible light image whose difference values is larger than threshold as a background totem by a marking unit
810
END

FIG. 8

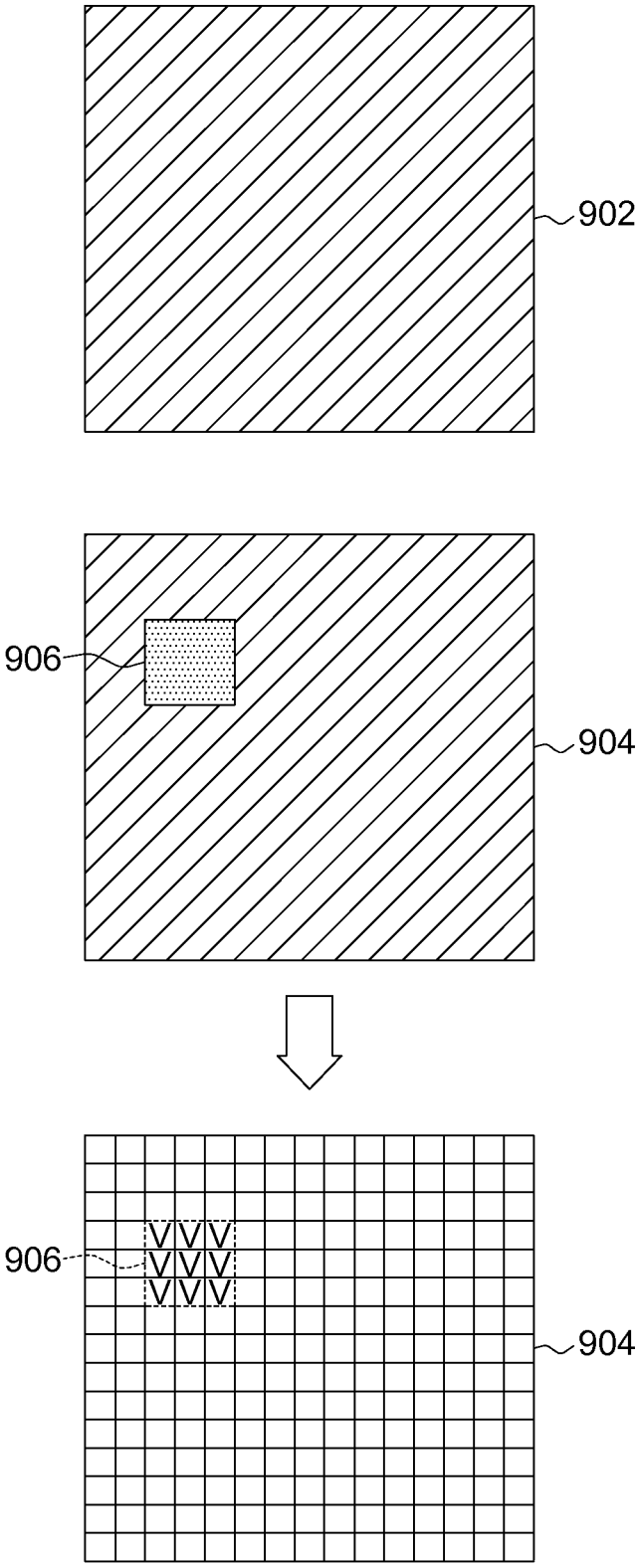

FIG. 9

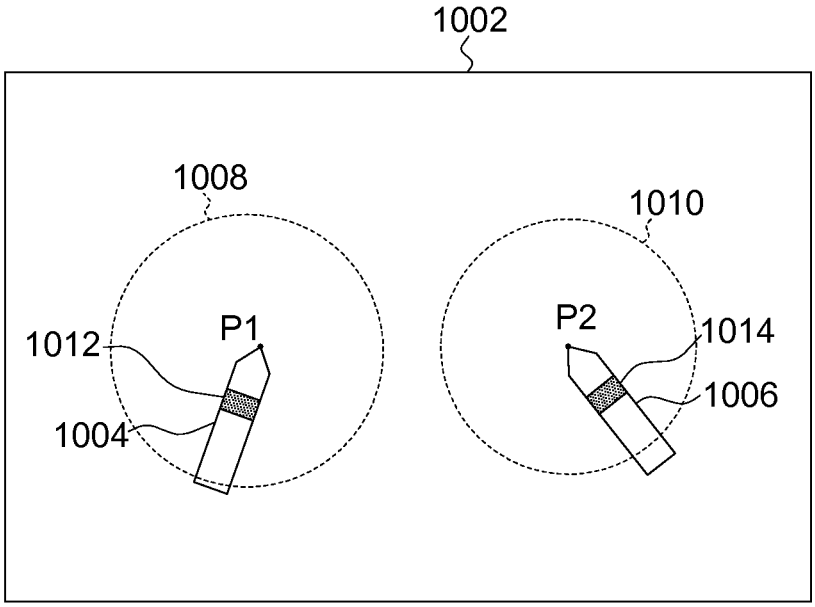
1002
1008
1010
P1
P2
1012
1014
1006
1004

FIG. 10

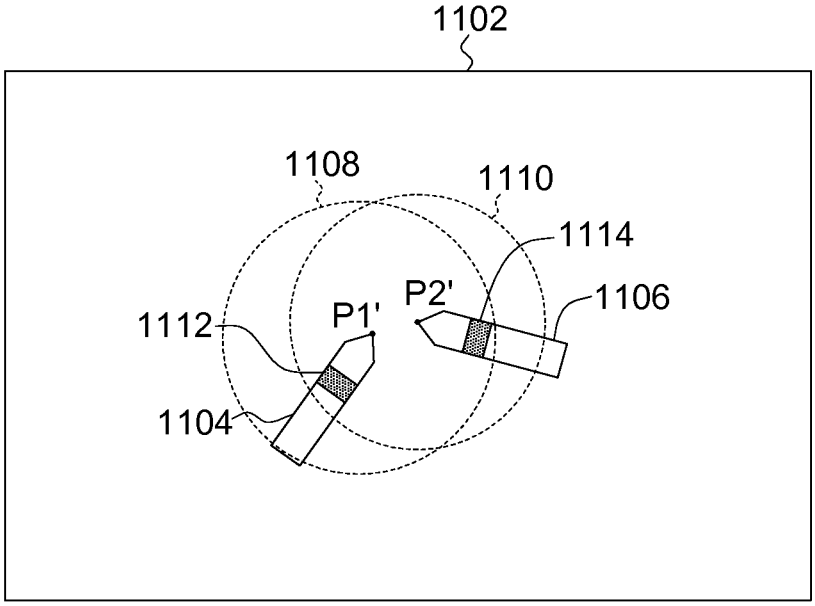
1102
1108
1110
1114
P2'
1106
P1'
1112
1104

FIG. 11

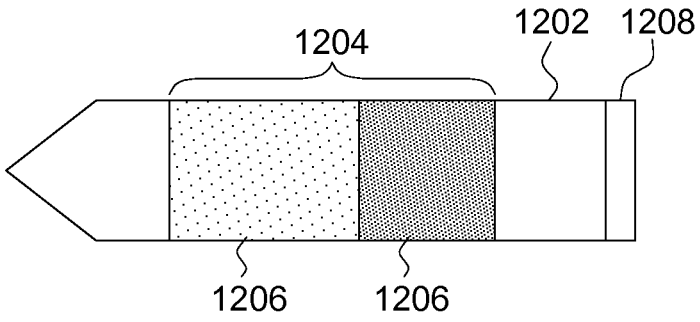

FIG. 12A

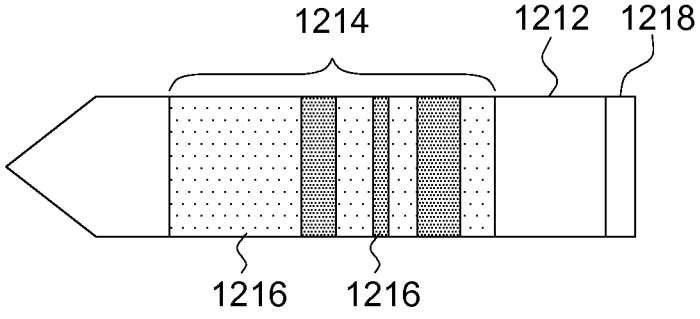

FIG. 12B

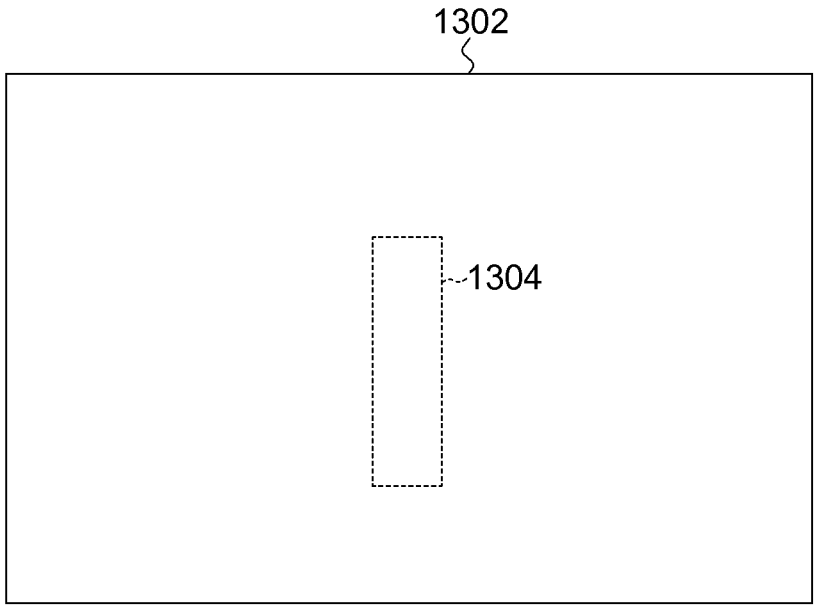

FIG. 13

INTERACTIVE WRITING DEVICE AND OPERATING METHOD THEREOF USING ADAPTIVE COLOR IDENTIFICATION MECHANISM

This application claims the benefit of Taiwan application Serial No. 102146248, filed Dec. 13, 2013, the disclosure of which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

The disclosure relates in general to an interactive writing device and an operating method thereof, and more particularly to an interactive writing device and an operating method thereof using adaptive color identification mechanism.

BACKGROUND

In recent years, technology of interactive projection or interactive whiteboard has become more and more popular. Conventionally, the interactive pen and display device of the interactive projector utilize radio waves to transmit data. This kind of interactive pen usually has the function of wireless mouse. The user can select writing color by pressing the button of the interactive pen or using the interactive pen to click on the function menu shown on a frame.

However, conventionally, when the user wants to change the writing color, the user has to enter a function menu with several times of clicking. Besides, conventional interactive projection system normally only supports one writing color in the same writing region.

SUMMARY

The disclosure is directed to an interactive writing device and an operating method thereof using adaptive color identification mechanism.

According to one embodiment, an operating method for an interactive writing device is provided. The operating method includes following steps. A visible light image is captured in response to an original outputted image. A tag searching region is established in the visible light image in response to a writing operation performed by a writing object having a color tag pattern. The original outputted image corresponding to the tag searching region is filtered from the visible light image in the tag searching region to generate a local processed image. A color tag corresponding to the color tag pattern of the writing object is searched from the local processed image. A color value corresponding to the color tag is generated.

According to another embodiment, an interactive writing device is provided. The interactive writing device includes a capturing unit and a processing unit. The capturing unit fetches a visible light image in response to an original outputted image. The processing unit is coupled to the capturing unit, and includes a search region establishing unit, a color recovery unit, a tag searching unit and a display control unit. The search region establishing unit establishes the tag searching region in the visible light image in response to a writing operation performed by a writing object having a color tag pattern. The color recovery unit filters the original outputted image corresponding to the tag searching region from the visible light image in the tag searching region to generate a local processed image. The tag searching unit searches a color tag corresponding to the color tag pattern of the writing object from the local processed image. The display control unit generates a color value corresponding to the color tag.

According to an alternative embodiment, an interactive writing device used in an interactive whiteboard or an interactive projection device is provided. The interactive writing device includes a capturing unit and a processing unit. The capturing unit fetches a visible light image in response to an original outputted image. The processing unit is coupled to the capturing unit, and includes a search region establishing unit, a color recovery unit, a tag searching unit and a display control unit. The search region establishing unit establishes the tag searching region in the visible light image in response to a writing operation performed by a writing object having a color tag pattern. The color recovery unit filters the original outputted image corresponding to the tag searching region from the visible light image in the tag searching region to generate a local processed image. The tag searching unit searches a color tag corresponding to the color tag pattern of the writing object from the local processed image. The display control unit generates a color value corresponding to the color tag.

The above and other aspects of the invention will become better understood with regard to the following detailed description of the preferred but non-limiting embodiment (s). The following description is made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an interactive writing device according to an embodiment of the disclosure.

FIG. **2** is a flowchart of an operating method for an interactive writing device.

FIG. **3**A is a schematic diagram of a projector projecting an original outputted image to a projection region.

FIG. **3**B is a schematic diagram of a writing object performing writing operation in projection region.

FIG. **3**C is a schematic diagram of a local processed image.

FIG. **4** is another example of a search region establishing unit establishing a tag searching region.

FIG. **5** is another example of a search region establishing unit establishing a tag searching region.

FIG. **6** is an interactive writing device according to another embodiment of the disclosure.

FIG. **7** is a block diagram of a background totem identification unit.

FIG. **8** is a flowchart of an operating method of a background totem identification unit.

FIG. **9** is a schematic diagram of background totem marked in a visible light image.

FIG. **10** is a schematic diagram of an example of writing operation performed by several writing objects having color tag pattern.

FIG. **11** is a schematic diagram of another example of writing operation performed by several writing objects having color tag pattern.

FIG. **12**A is a schematic diagram of an example of a color tag pattern according to an embodiment of the disclosure.

FIG. **12**B is a schematic diagram of another example of a color tag pattern according to an embodiment of the disclosure.

FIG. **13** is a schematic diagram of an example of a color calibration frame generated by an interactive writing device according to an embodiment of the disclosure.

In the following detailed description, for purposes of explanation, numerous specific details are set forth in order

to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

DETAILED DESCRIPTION

A number of embodiments are disclosed below for elaborating the disclosure. However, the embodiments of the disclosure are for detailed descriptions only, not for limiting the scope of protection of the disclosure. Furthermore, secondary or unimportant elements are omitted in the accompanying diagrams of the embodiments for highlighting the technical features of the disclosure.

Referring to FIG. **1** and FIG. **2**, FIG. **1** is a block diagram of an interactive writing device **100** according to an embodiment of the present disclosure and FIG. **2** is a flowchart of an operating method for the interactive writing device **100**. The interactive writing device **100** includes a capturing unit **102** and a processing unit **104**. The processing unit **104** includes a search region establishing unit **106**, a color recovery unit **108**, a tag searching unit **110** and a display control unit **112**. The capturing unit **102** is, for example, a light capturing device, such as a camera. The processing unit **104** is, for example, an integrated circuit or other processor with computational capability. The search region establishing unit **106**, the color recovery unit **108**, the tag searching unit **110** and the display control unit **112** respectively can be realized by an operation processing circuit having corresponding function or a software program enabling the processing unit **104** to execute corresponding function.

In step **202**, the capturing unit **102** captures a visible light image in response to an original outputted image. The original outputted image is, for example, an image projected by a projector or an interactive projection device, or an image displayed on a monitor (such as an interactive whiteboard). After the original outputted image was outputted (for example, after the image is projected or displayed on a whiteboard or an electronic whiteboard), the capturing unit **102** shoots the original outputted image projected on the whiteboard to generate a corresponding visible light image. The visible light image is, for example, a digital image shot by a visible light camera, wherein the color of the image content falls in a visible light range.

In step **204**, the search region establishing unit **106** establishes a tag searching region in the visible light image in response to a writing operation performed by a writing object. The writing object is, for example, an electronic whiteboard pen or other object that can be used for writing purposes, such as a pen-like object or a finger. The writing object can be used for writing on an ordinary whiteboard or an electronic whiteboard. The writing object includes a color tag pattern. The color tag pattern can be used for indicating the writing color of the writing object. For example, if the writing object includes a red color tag pattern, the writing color of the writing object is red. The color tag pattern shot by the capturing unit **102** can be regarded as a color tag in the visible light image. The tag searching region defines the region in which the color tag may appear in the visible light image. The size of the region is, for example, smaller than the size of the entire visible light image.

In step **206**, the color recovery unit **108** filters out the original outputted image corresponding to the tag searching region from the visible light image in the tag searching region to generate a local processed image. Specifically, since the content of the original outputted image is known, the original outputted image can be filtered out from the visible light image or the composition of the original outputted image in the visible light image can be reduced by using image processing technologies, so that the color of the visible light image in the tag searching region will be less affected by the original outputted image.

In step **208**, the tag searching unit **110** searches a color tag corresponding to the color tag pattern of the writing object from the local processed image. Since the color of the content in the local processed image is highlighted (or recovered), the tag searching unit **110** can identify the position of the color tag according to the color value corresponding to each image point of the local processed image.

In step **210**, the display control unit **112** generates a color value corresponding to the color tag. For example, the display control unit **112** may analyze the color composition of the color tag and perform color classification according to the color components to obtain a color value corresponding to the color tag. The color value is, for example, an RGB image value or an image value corresponding to other color space, such as a YCbCr image value.

According to the above, the interactive writing device **100** of the present embodiment of the disclosure can effectively remove color interference, caused by the original outputted image, from the color tag pattern of the writing object. In addition, by means of establishing the tag searching region, the interactive writing device **100** not only effectively reduces the computational cost required for searching the color tag but also reduces the chance of misjudging the color tag.

In another example, after the interactive writing device **100** identifies the color value corresponding to the color tag, the display control unit **112** may activate a specific or a predetermined function (such as opening the whiteboard, activating a writing function, activating a specific color, activating a specific font, and so on) for the user to perform different operations. Alternatively, the display control unit **112** may activate a predetermined function according to the color value corresponding to the color tag in response to the writing operation of the writing object. For example, after the interactive writing device **100** of the present embodiment of the disclosure identified the color value, the interactive writing device **100** not only shows the writing trace of the writing object but also executes other function. For example, the white color can be used as a rubber, a left key or right key of a mouse, or a writing pad.

For illustration, the operations of the interactive writing device **100** are described below with the reference to FIGS. **3A-3C**. The scenarios shown in FIGS. **3A-3C** are exemplified by using an interactive projection device. The user uses a writing object (such as an electronic whiteboard pen) including a color tag pattern to perform a writing operation in a projection region. By means of the interactive writing device **100**, the writing trace formed by the writing object shows a color corresponding to the color tag pattern. It is understood that the present disclosure is not limited to above examples.

Referring to FIG. **3A**, a schematic diagram of a projector **300** projecting an original outputted image **302** onto a projection region **304** is shown. In the present example, the interactive writing device **100** is coupled to the projector **300** and obtains the information of the original outputted image through data transmission. The interactive writing device **100** further uses the capturing unit **102** to shoot the projection region **304** to generate a corresponding visible light

image. In the scenario of FIG. **3**A, the projector **300** projects a pure green original outputted image **302** to the projection region **304**.

Referring to FIG. **3**B, a schematic diagram of a writing object **306** (such as an electronic whiteboard pen) performing a writing operation in the projection region **304** is shown. In the present example, the writing object **306** includes a color tag pattern **308** which is pure red under the irradiation of a white light source. Since the color tag pattern **308** is affected by the original outputted image **302** (pure green) projected on the projection region **304**, for the capturing unit **102** of the interactive writing device **100**, the image of the color tag obtained from the color tag pattern **308** will not correspond to the pure red color value but will correspond to a near black color value instead.

On the other hand, when writing operation is performed by the writing object **306** in the projection region **304**, the interactive writing device **100** can generate a position information (for example, the coordinates in the image) of a writing point P by the search region establishing unit **106**, and the tag searching region **310** is further established according to the position information of the writing point P. As can be seen from FIG. **3**B, the position of the writing point P falls within the tag searching region **310**, and the range of the tag searching region **310** appropriately covers the color tag corresponding to the color tag pattern **308**. In other words, the interactive writing device **100** only needs to search the color tag from the vicinity of the writing point P (equivalent to the tip of the writing object **306**). Thus, the computational cost required for searching the color tag can be significantly reduced. It is understood that the tag searching region **310** of the present embodiment of the disclosure is not limited to the circular shape illustrated in FIG. **3**B. Suppose the actual distance D between the writing end of the writing object **306** (such as the tip of the writing object **306**) and the color tag pattern **308** corresponds to a predetermined length (e.g., N-pixel length, and N is a positive integer larger than 1) in the visible light image, the maximum distance between the position of the writing point P and a boundary of the tag searching region **310** can be set to be at least larger than the predetermined length.

In the present example, when the writing operation is performed by the writing object **306** in the projection region **304**, an infra-red light spot will be generated at the starting point of writing. After detecting the infra-red light spot by the capturing unit **102**, the capturing unit **102** transmits position information of the infra-red light spot to the search region establishing unit **106**, and a position information corresponding to the writing point P is generated accordingly by the search region establishing unit **106**.

Referring to FIG. **3**C, a schematic diagram of a local processed image **312** is shown. In the present example, the color recovery unit **108** filters the original outputted image corresponding to the tag searching region **310** from the visible light image in the tag searching region **310** to generate a local processed image **312**. Then, the display control unit **112** analyses the color composition on the color tag in the local processed image **312** and performs color classification according to the color components to obtain a color value corresponding to the color tag. Taking the scenario of the present embodiment as an example. Suppose that the RGB color values of the color tag region respectively are 120(R)/180(G)/80(B) before the original outputted image **302** is filtered from the visible light image in the tag searching, through the image processing performed by the color recovery unit **108**, the RGB color values of the color tag become 200(R)/80(G)/50(B) or 50(R)/30(G)/20(B) respectively. Meanwhile, since the RGB color values of the color tag are obviously inclined to the red color classification, the display control unit **112** classifies the color value corresponding to the color tag as red (suppose the display control unit **112** already knows that the color tag of the writing object could be red, blue or green). Moreover, suppose that the RGB color values of a color block respectively are 80(R)/200(G)/80(B) before the original outputted image **302** is filtered, through the image processing performed by the color recovery unit **108**, the RGB color values of the color block become 100(R)/100(G)/100(B) respectively. Meanwhile, since the RGB color values of the color tag are not inclined to any particular color classification, the color block is regarded as a "unmarked color block". The unmarked color blocks can be removed from the tag searching region **310**.

It is understood that the color tag pattern of the present embodiment of the disclosure is not limited to the patterns illustrated in FIGS. **3**A-**3**C. For example, the color tag pattern may include two parts: color region and color code. Alternatively, the shape of the color tag pattern can be other than a rectangle. For example, the shape of the color tag pattern can further extend from the tip of the writing object. Or, the color tag pattern can be any shape on a writing object including color region and color code.

In the scenarios of FIGS. **3**A-**3**C, the search region establishing unit **106** establishes the tag searching region **310** according to the position of the writing point P. However, the disclosure is not limited thereto. The search region establishing unit **106** can also establish the tag searching region by other means exemplified in FIG. **4** and FIG. **5** below.

Referring to FIG. **4**, another example of a search region establishing unit **106** establishing a tag searching region is shown. As shown in FIG. **4**, the original outputted image **402** is projected onto the projection region **404**. When the writing object **406** is used for writing, the interactive writing device **100** uses the capturing unit **102** to obtain a corresponding visible light image. Then, the search region establishing unit **106** identifies the shape of the writing object **406** (for example, the outer contour of the writing object **406**) in the visible light image to establish a corresponding tag searching region **408** according to the shape of the writing object **406**.

In an example, the search region establishing unit **106** identifies the shape of the writing object **406** according to the features of the shape of the writing object **406** (such as the tip of the writing object **406**) to establish a tag searching region **408** corresponding to the shape of the writing object **406**. As indicated in FIG. **4**, the search region establishing unit **106** can search the color tag corresponding to the color tag pattern **410** from the morphological region of the writing object **406**, so that the chance of misjudging the color tag can be effectively reduced.

Referring to FIG. **5**, another example of a search region establishing unit **106** establishing a tag searching region is shown. As shown in FIG. **5**, images **502** and **504** are visible light images shot by the capturing unit **102** at time points t**1** and t**2** respectively. The writing operation of the writing object **506** is performed by moving the writing object **506** from left side to right side. Thus, in FIG. **5**, the writing object **506** generates a writing point P**1** at the left hand side of the image at the time point t**1**, and generates a writing point P**2** at the right hand side of the image at the time point t**2**. Therefore, through dynamic movement tracking (e.g, obtaining the information of moving portion and moving vector in an image by detecting how the image value of each

image point varies with the time), the search region establishing unit **106** can identifies the shape or position of the writing object **506**, and correspondingly adjusts the range of the tag searching region in which the color tag pattern **508** can be easily searched. For example, the range of the tag searching region is restricted to be within the morphological range of the writing object **506** as possible. In other words, during the period in which the writing object **506** performs a writing operation, the capturing unit **102** sequentially captures a plurality of visible light images corresponding to different time points. The search region establishing unit **106** compares the visible light images corresponding to different time points to generate an image movement information corresponding to the writing object **506** and further establishes a tag searching region according to the image movement information. Thus, even though the writing object **506** performs a writing operation in a region having complicated background, the search region establishing unit **106** still can establish an effective tag searching region in which the color tag pattern **508** can be easily searched.

FIG. **6** is an interactive writing device **600** according to another embodiment of the disclosure. The interactive writing device **600** includes a capturing unit **602** and a processing unit **604**. The processing unit **604** includes a search region establishing unit **606**, a color recovery unit **608**, a tag searching unit **610**, a display control unit **612** and a background totem identification unit **614**. The interactive writing device **600** of the present embodiment is different from the interactive writing device of above embodiments in that the interactive writing device **600** further includes a background totem identification unit **614**. The background totem identification unit **614** generates a background totem according to the difference between the original outputted image and the visible light image, and further marks the background totem in the visible light image. When the tag searching unit **610** searches for the color tag, the part of the visible light image marked as the background totem is ignored. Therefore, the interactive writing device **600** of the present embodiment can effectively avoid background object interfering with the identification of the color tag.

Referring to FIG. **7** and FIG. **8**. FIG. **7** is a block diagram of a background totem identification unit **614**. FIG. **8** is a flowchart of an operating method **800** of a background totem identification unit **614**. The background totem identification unit **614** includes a buffer **702**, a synchronizer **704**, an image splitter **706**, a comparator **708** and a marking unit **710**.

In step **802**, the buffer **702** temporarily stores an original outputted image. The original outputted image is outputted through an external device such as a projector or a monitor.

In step **804**, the synchronizer **704** synchronizes the original outputted image and the visible light image captured by the capturing unit **602**, such that the original outputted image and the captured visible light image correspond to the same time point. Take the the original outputted image outputted by a projector for example. The time point at which the projector outputs the original outputted image is slightly different from the time point at which the capturing unit **602** captures the corresponding visible light image. Therefore, the original outputted image and the visible light image can be synchronized by the synchronizer **704** so that the original outputted image and the visible light image have the same time mark M.

In step **806**, the image splitter **706** respectively divides the original outputted image and the visible light image into several image blocks. The image blocks include different image values (such as RGB pixel values) corresponding to the content of the image. In an example, a space mark F is further assigned to each image block. For example, space mark F=30 indicates an image block **30** of the image.

In step **808**, the comparator **708** compares the image values corresponding to the image block of the original outputted image with the image values corresponding to the image block at corresponding positions of the visible light image to generate a difference value between each image block of the visible light image and each image block of the original outputted image. For example, with regard to the original outputted image and the visible light image that have the same time mark M, the comparator **708** compares the image values of the image blocks of the two images that have the same space mark F to obtain a difference value corresponding to each image block.

In step **810**, the marking unit **710** marks the image block of the visible light image whose difference values is larger than threshold T as a background totem. If the image value difference between the image value corresponding to a particular image block of the visible light image (such as the image block with time mark M=10 and space mark=50) and the image value corresponding to an image block of the original outputted image (such as the image block with time mark M=10 and space mark=50) is larger than a predetermined measure (that is, threshold T), it can be determined that the image block may be a background totem, and does not belong to the image content of the original outputted image.

Referring to FIG. **9**, a schematic diagram of background totem marked in a visible light image is shown. As shown in FIG. **9**, taking the interactive projection device as an example, the image **902** is an original outputted image outputted by way of projection, the image **904** is a visible light image shot by the capturing unit **602**. In the present example, the projection region of the original outputted image **902** includes a background object (such as a sticker on the wall), and thus the visible light image **904** has a pattern **906** of the background object. After sequentially comparing the image blocks of the original outputted image **902** with the image blocks of the visible light image **904**, it can be decided that the image blocks corresponding to the pattern **906** are significantly different from the image blocks corresponding to the original outputted image **902**. After the image blocks with significant differences are marked in the visible light image **904** (denoted by ticked lattice in FIG. **9**), the marking of the background totem is completed.

Referring to FIG. **10**, a schematic diagram of an example of writing operation performed by several writing objects having color tag patterns. As shown in FIG. **10**, within the writing region **1002**, two writing objects **1004** and **1006** respectively perform a writing operation and generate writing points P**1** and P**2** respectively corresponding to tag searching regions **1008** and **1010**. The writing objects **1004** and **1006** respectively include color tag patterns **1012** and **1014**. Since the writing objects **1004** and **1006** are separated by a larger distance (the tag searching regions **1008** and **1010** are not overlapping), the interactive writing device of the present embodiment can decide the color values of the color tags corresponding to the color tag patterns **1012** and **1014** on the writing objects **1004** and **1006** by means of color tag searching and color recovery mechanism disclosed above and further generate writing traces having corresponding colors. Suppose the color of the color tag pattern **1012** on the writing object **1004** is recovered by the interactive writing device of the present embodiment, the value of the recovered color is corresponding to blue color value. Meanwhile, the writing trace generated in the writing operation performed by the writing object **1004** shows blue.

Similarly, the color of the color tag pattern **1014** of the writing object **1006** is recovered by the interactive writing device of the present embodiment of the disclosure, and the value of the recovered color is corresponding to red color value. Meanwhile, the writing trace generated in the writing operation performed by the writing object **1004** shows red.

Referring to FIG. **11**, a schematic diagram of another example of writing operation performed by several writing objects having color tag pattern is shown. As indicated in FIG. **11**, within the writing region **1102**, two writing objects **1104** and **1106** respectively perform writing operation and generate writing points P**1'** and P**2'** respectively corresponding to tag searching regions **1108** and **1110**. The writing object **1104** and **1106** respectively have color tag patterns **1112** and **1114**. In the present example, the writing objects **1104** and **1106** are separated be a shorter distance (the tag searching regions **1108** and **1110** are overlapping). Suppose the writing objects **1104** and **1106** start writing at different time points (for example, the generation time of the writing point P**1'** is earlier than that of the writing point P**2'**), the interactive writing device of the present embodiment can firstly decide the color value corresponding to the color tag of the color tag pattern **1112** on the writing object **1104** according to the color tag searching and color recovery mechanism. For example, the color recovery unit generates a local processed image corresponding to the tag searching region **1108**, the tag searching unit searches the color tag corresponding to the color tag pattern **1112** from the local processed image, and then the display control unit generates a color value corresponding to the color tag. Then, when the writing object **1106** starts to write, the background totem identification unit marks the color tag corresponding to the color tag pattern **1112** as a background totem. After the color value corresponding to the color tag pattern **1112** was interpreted, the color tag pattern **1112** is temporarily regarded as a background totem. Even though the tag searching region **1110** corresponding to the writing object **1106** covers both the color tag pattern **1112** and **1114**, the interactive writing device of the present embodiment still can complete color interpretation of the color tag pattern **1114** by means of color tag searching and color recovery mechanism disclosed above.

In another situation, the writing objects **1104** and **1106** start writing at the same time (for example, the generation time of the writing point P**1'** is the same as that of the writing point P**2'**), the interactive writing device of the present embodiment can firstly decide the color value corresponding to the color tag pattern **1112** on one of the writing objects (the present example is exemplified by the writing object **1104**) by means of color tag searching and color recovery mechanism disclosed above. Then, the tag searching unit searches the color tag corresponding to another color tag pattern **1114** from the local processed image that is generated by the color recovery unit and corresponding to the tag searching region **1110**. The display control unit sets the color value corresponding to the color tag of another color tag pattern **1114** as a predetermined value. The predetermined value, for example, corresponds to a particular or initial color (such as black), or corresponds to a color of the color tag not corresponding to the color tag pattern **1112** (such as a writing color that has not been used).

Referring to FIG. **12**A, a schematic diagram of an example of a color tag pattern according to an embodiment of the disclosure is shown. As indicated in FIG. **12**A, the writing object **1202** has a color tag pattern **1204**. The color tag pattern **1204** has several color blocks **1206** (only two color blocks **1206** are illustrated in FIG. **12**A but the disclosure is not limited thereto). Based on the colors, areas and/or positions of the color blocks **1206**, the display control unit of the interactive writing device of the present embodiment can decide the color value corresponding to the color tag pattern **1204**. For example, through suitable arrangement in area proportions of the color blocks **1206**, the color saturation of the writing trace of the writing object **1202** can be adjusted.

In another example, the writing object **1202** further has an actual color pattern **1208**. The color of the actual color pattern **1208** is substantially equivalent to the color of the writing trace of the writing object **1202**. Therefore, the user can understand the color of the writing trace of the writing object **1202** through the color of the actual color pattern **1208** to get closer to the actual scenario of writing on a whiteboard.

Referring to FIG. **12**B, a schematic diagram of another example of a color tag pattern according to an embodiment of the disclosure is shown. As shown in FIG. **12**B, the color tag pattern **1214** includes several color blocks **1216**. The colors, areas, sizes and/or positions of the color blocks **1216** can be adjusted according to the required writing colors (similar to the bar code but is not limited thereto). For example, through suitable arrangement in the quantity, widths and area proportions of the color blocks **1216**, color saturation or corresponding color of the writing trace of the writing object **1212** can be adjusted. In the present example, the writing object **1212** can selectively include an actual color pattern **1218** with which the user can identify the color of the writing trace.

Referring to FIG. **13**, a schematic diagram of an example of a color calibration frame **1302** generated by an interactive writing device according to an embodiment of the disclosure is shown. The color calibration frame **1302** is projected to or displayed on a wall or whiteboard. As shown in FIG. **13**, the color calibration frame **1302** has a calibration region **1304** indicating the user to place the writing object including the tag pattern with specific color in the calibration region. For example, the calibration region **1304** indicates that the electronic whiteboard pen having a red tag be placed in the calibration region **1304**. It is understood that although the calibration region **1304** of FIG. **13** is exemplified by a rectangular pattern, the disclosure is not limited thereto, and the pattern of the calibration region **1304** can be designed to fit practical applications. Meanwhile, when the user places the corresponding writing object (such as the electronic whiteboard pen having red tag) in the calibration region **1304**, the capturing unit shoots the writing object to fetch a visible light calibration image. Then, the tag searching unit searches the color tag from the visible light calibration image, and the display control unit sets the color value corresponding to the color tag as a predetermined color value (such as a red color value). Thus, the interactive writing device of the present embodiment can pre-define the color value corresponding to each the color tag by using color calibration mechanism disclosed above to avoid the light source interfering with color interpretation.

To summarize, the interactive writing device of the present embodiment can correctly identify the color value corresponding to the color tag pattern on the writing object. Also, by means of establishing the tag searching region, the interactive writing device of the present embodiment not only effectively reduces the computational cost required for searching the color tag but also reducing the chance of misjudging the color tag. In addition, marking the back-

ground totem not only reduces the chance of misjudging the color tag but also help with identifying the colors of multiple color tags.

It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed embodiments. It is intended that the specification and examples be considered as exemplary only, with a true scope of the disclosure being indicated by the following claims and their equivalents.

What is claimed is:

1. An operating method for an interactive writing device, comprising:

capturing a visible light image in response to an original outputted image;

establishing a tag searching region in the visible light image in response to a writing operation performed by a writing object, wherein the writing object includes a color tag pattern;

filtering out the original outputted image corresponding to the tag searching region from the visible light image in the tag searching region to generate a local processed image;

searching a color tag corresponding to the color tag pattern of the writing object from the local processed image; and

generating a color value corresponding to the color tag,

wherein the step of establishing the tag searching region comprises:

generating a writing point in response to the writing operation performed by the writing object; and

establishing the tag searching region according to the position of the writing point which falls within the tag searching region.

2. The operating method according to claim **1**, wherein a distance between a writing end of the writing object and the color tag pattern corresponds to a predetermined length in the visible light image, and the maximum distance between the writing point and a boundary of the tag searching region at least is larger than the predetermined length.

3. The operating method according to claim **1**, wherein the step of establishing the tag searching region comprises:

identifying the shape of the writing object from the visible light image; and

establishing the tag searching region according to the shape of the writing object.

4. The operating method according to claim **1**, wherein the step of establishing the tag searching region comprises:

sequentially capturing a plurality of visible light images at different time points during a period in which the writing object performs the writing operation;

comparing the visible light images corresponding to different time points to generate an image movement information corresponding to the writing object; and

establishing the tag searching region according to the image movement information.

5. The operating method according to claim **1**, further comprising:

generating a background totem according to a difference between the original outputted image and the visible light image; and

marking the background totem in the visible light image;

wherein, when said searching the color tag is performed, a part of the visible light image marked as the background totem is ignored.

6. The operating method according to claim **5**, wherein the step of generating the background totem comprises:

temporarily storing the original outputted image;

synchronizing the original outputted image with the captured visible light image, so that the original outputted image and the captured visible light image are corresponding to the same time point;

dividing the original outputted image and the visible light image into a plurality of image blocks respectively corresponding to an image value;

comparing the image values corresponding to the image blocks of the original outputted image with the image values corresponding to the image blocks at corresponding positions of the visible light image to generate a difference value between each image block of the visible light image and each image block of the original outputted image; and

marking the image block of the visible light image whose difference value is larger than a threshold as the background totem.

7. The operating method according to claim **5**, further comprising:

generating a first writing point corresponding to a first tag searching region at a first time point;

generating a second writing point corresponding to a second tag searching region at a second time point, wherein the second tag searching region partially or completely overlaps the first tag searching region;

filtering the original outputted image corresponding to the first tag searching region from the first visible light image in the tag searching region to generate a first local processed image, and searching a first color tag from the first local processed image to generate the color value corresponding to the first color tag; and

after the color value of the first color tag is generated, marking the first color tag as the background totem, and filtering the original outputted image corresponding to the second tag searching region from the second visible light image in the tag searching region to generate a second local processed image, and searching a second color tag from the second local processed image to generate the color value corresponding to the second color tag.

8. The operating method according to claim **1**, further comprising:

detecting a first writing point and a second writing point at a first time point, wherein the first writing point and the second writing point are respectively corresponding to a first tag searching region and a second tag searching region partially or completely overlapping the first tag searching region;

filtering the original outputted image corresponding to the first tag searching region from the first visible light image in the tag searching region to generate a first local processed image, and searching a first color tag from the first local processed image to generate the color value corresponding to the first color tag; and

searching a second color tag from the second tag searching region, and setting the color value corresponding to the second color tag as a predetermined value.

9. The operating method according to claim **1**, wherein the color tag comprises a plurality of color blocks, and the method further comprises:

determining the color value corresponding to the color tag according to the color blocks.

10. The operating method according to claim **1**, further comprising:

providing a color calibration frame, wherein the color calibration frame has a calibration region indicating the writing object to be the placed therein;

shooting the writing object and fetching a visible light calibration image from the image of the writing object when the writing object is placed in the calibration region; and

searching the color tag corresponding to the color tag pattern of the writing object from the visible light calibration image; and

setting the color value as a predetermined color value.

11. The operating method according to claim **1**, further comprising:

displaying a trace having the color value in response to the writing operation performed by the writing object.

12. The operating method according to claim **1**, further comprising:

activating a predetermined function according to the color value corresponding to the color tag in response to the writing operation performed by the writing object.

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